Progress Report No. 4

HEAT TRANSFER DURING SUBCOOLED BOILING

Department of Mechanical Engineering
Stanford University

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Professor George Leppert, Chief Investigator

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Statement of the Problem Studied

This research project has been concerned with the analysis and measurement of heat transfer from a cylindrical tube to liquid in cross-flow. Although primary interest has been in the subcooled nucleate boiling regime with forced convection, significant and original results have been obtained for forced convection without boiling, for saturated nucleate boiling and for pool boiling.

Results and Conclusions Reached

1. Average heat transfer coefficients on a uniformly heated cylinder. New experimental data were presented for a Reynolds number range from 40 to 100,000 and for Prandtl numbers from 1 to 300. The effects of temperature differences large enough to produce significant changes in viscosity across the boundary layer were correlated in terms of a viscosity ratio.

2. Local heat transfer coefficients on a uniformly heated cylinder. Analysis of the heat transfer in the laminar boundary layer using integral methods was compared with original experimental measurements of the local heat transfer coefficents around a cylinder. The influence of channel blockage was investigated and a correction for this effect was presented. Free stream turbulence was measured and discussed.

3. Critical heat flux for nearly saturated water flowing normal to a cylinder. Visual and photographic observations were used to construct a physical model of transition from nucleate to film boiling. An approximate analysis was developed to predict the critical flux for the saturated nucleate-boiling case. Measurements of this peak flux were reported for a wide range of velocities,

diameters and wall thicknesses.

4. Critical heat flux for subcooled water flowing normal to a cylinder. Original experimental data were presented showing the effects of diameter, water velocity and subcooling on the critical heat flux from an electrically heated, cylindrical tube or wire. The maximum flux which can be accommodated in subcooled nucleate boiling varies directly with the velocity and subcooling and inversely with a fractional power of the heater diameter.

Publications and Technical Reports

1. G. C. Vliet, "Local Boiling Peak Heat Flux for Water Flowing Normal to Cylinders", Ph. D. thesis in Mechanical Engineering, Stanford University, 1962.

2. H. C. Perkins, Jr., "Forced Convection Heat Transfer from a Uniformly Heated Cylinder", Ph. D. thesis in Mechanical Engineering, Stanford University, 1962.

3. H. C. Perkins, Jr. and G. Leppert, "Forced Convection Heat Transfer from a Uniformly Heated Cylinder", Trans. ASME, J. Heat Transfer, 84(1962)257.

4. G. C. Vliet and G. Leppert, "Critical Heat Flux for Nearly Saturated Water Flowing Normal to a Cylinder", to be published in Trans. ASME, J. Heat Transfer.

5. G. C. Vliet and G. Leppert, "Critical Heat Flux for Subcooled Water Flowing Normal to a Cylinder", to be published in Trans. ASME, J. Heat Transfer.

6. H. C. Perkins, Jr. and G. Leppert, "Local Heat Transfer Coefficients on a Uniformly Heated Cylinder", submitted for publication to Int. J. Heat and Mass Transfer.

7. G. Leppert and C. C. Pitts, "Boiling", to be published in Advances in Heat Transfer, Volume 1, 1963, Acaemic Press.

Scientific Personnel Employed

1. George Leppert, Professor of Mechanical Engineering, Principal Investigator.

2. Gary C. Vliet, Research Assistant. Ph. D. degree received in June 1962.

3. Henry C. Perkins, Jr., Research Assistant. Ph. D. degree received in December 1962.

4. Carl C. Pitts, Research Assistant. Ph. D. degree expected summer, 1963.

5. Neal P. Jeffries, Research Assistant.